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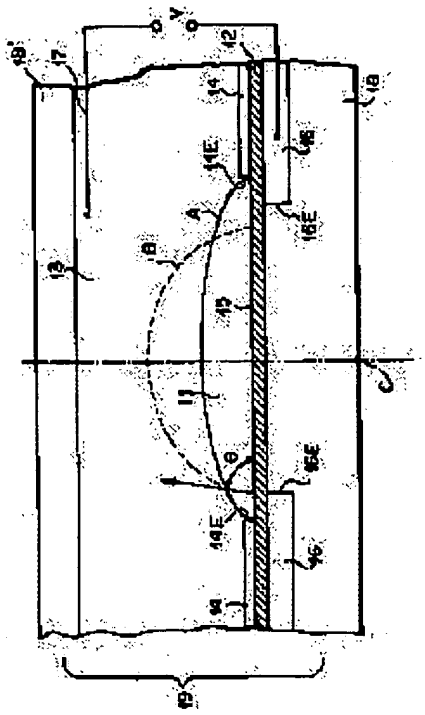
(54) VARIABLE FOCUS LENS DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a variable focus lens device in which the surface form of the lens can be stably maintained by suppressing the changes in the lens surface form against the changes in the external force having an effect on the liquid lens.

SOLUTION: A conductive liquid 13 containing a gelling agent and an insulating liquid drop 11 are housed in a cell 19, and a circular drop contact region 15 in contact with the drop 11 is formed on the inner surface of the cell. A surface layer 14 having lower affinity to the drop 11 than that of the insulating layer 12 is formed on the insulating layer 12, and an opening 14E is formed in a part of the layer 14 to expose a part of the insulating layer 12. The drop contact region 15 consists of the exposed part of the insulating layer. The interfacial form between the conductive liquid 13 and the drop 11 is changed by changing the voltage applied by a voltage applying means V between an electrode 16 on the opposite face of the insulating layer 12 to the conductive liquid 13 and the drop 11, and an electrode 17 in contact with the conductive liquid 13. The cell 19 has a light-transmitting property in the portion corresponding to the path of the incident and outgoing light on the interface.



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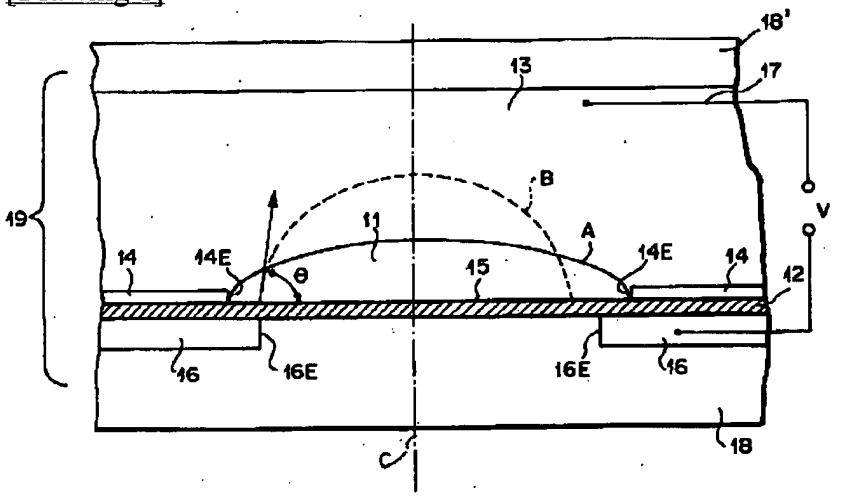
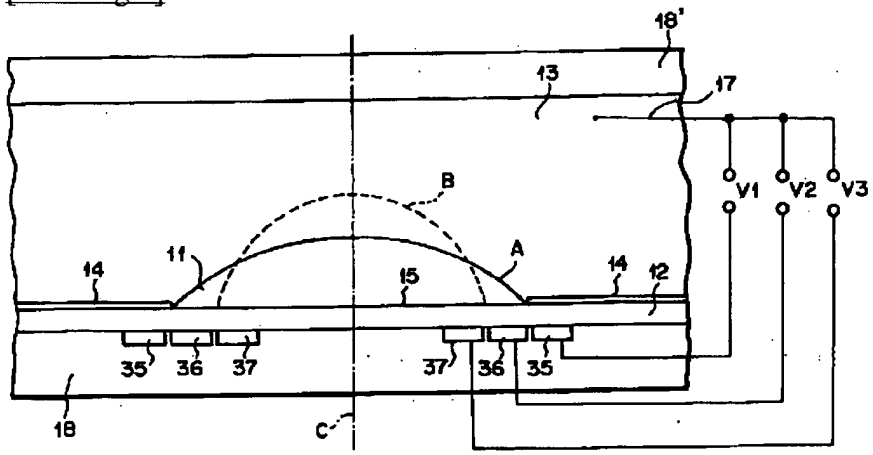
DRAWINGS

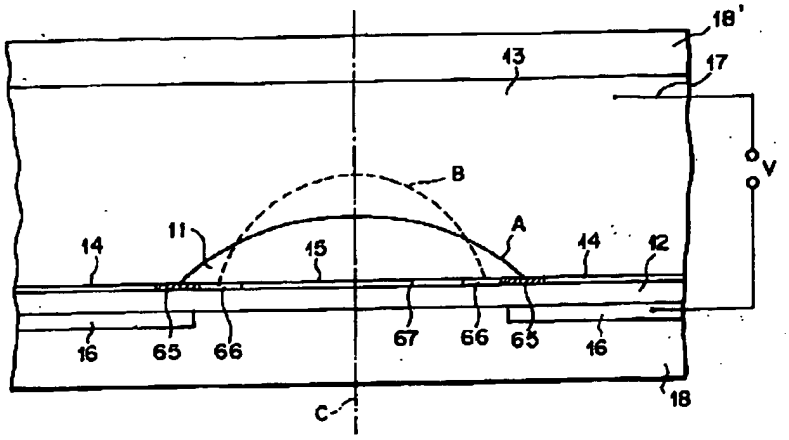
[Drawing 1]



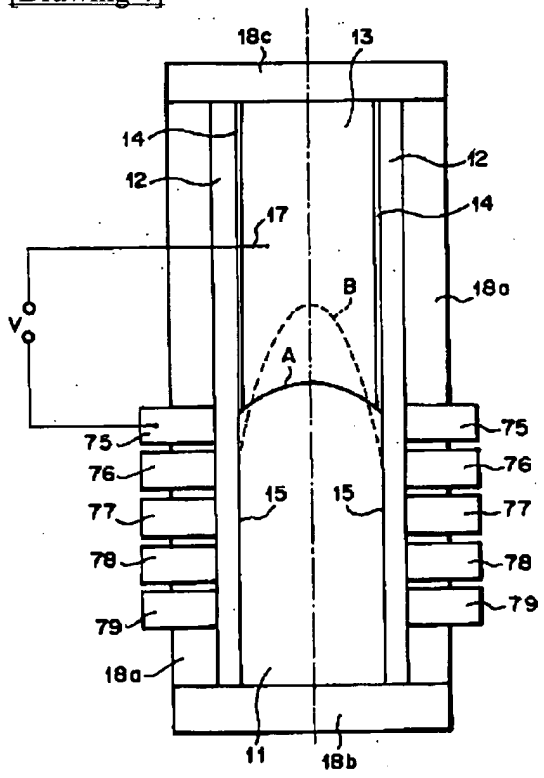
[Drawing 2]



[Drawing 3]



[Drawing 4]



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention belongs to the technical field of an optical element, and relates to the variable-focus lens equipment to which the shape of surface type of a liquid lens is changed especially by electrical-potential-difference impression, and a focal location is changed.
[0002]
[Description of the Prior Art] B. The device containing the conductive liquid globule placed on the dielectric film arranged on a plate electrode is shown in Berge's and others reference "Electrocapillarity andwetting of insulator films by water, C.R.Acad.Sci.Paris, t.137 p.157 (1993)." According to this reference, if an electrical potential difference is impressed between a conductive liquid globule and an electrode, it is described that the contact angle of the conductive liquid globule on a dielectric film changes, and this phenomenon is called electrowetting. However, in order to realize sufficient contact angle variation useful as an optical element, it is shown that about 600V needs to be high-tension impressed.
[0003] If the electrical potential difference impressed to a conductive liquid globule is too high, the front face of this globule becomes instability and it is shown in the reference "Electrowetting of water and aqueous solutionson poly (ethylene terephthalate), Polymer, Vol.37, No 12 p.2465 (1996)" of Vallet, Berge, Vovelle and others that it becomes impossible for a globule to maintain one configuration.
[0004] Thus, with these techniques, formation of a variable-focus lens stable enough cannot be performed, but since the junction electrode of a transparent electrode and a conductive liquid globule is still more nearly required of the system using these conventional technique, there is difficulty on a manufacturing technology and manufacture effectiveness is low.
[0005] No.97 by which the France country application was carried out on the other hand 12781 and INPI Grenoble and Oct. -- 8 and 1997 are related with the technique about the variable-focus lens equipment to which a focus can be continuously changed by electric-field control (armature-voltage control) using an electrowetting phenomenon.
[0006] However, if the external force which acts to a lens drop depending on the above conventional technique changes, it is difficult for the configuration of the front face of a lens drop to change easily, and to maintain the shape of surface type of a lens drop to stability. For example, if the variable-focus lens equipment of the conventional technique is leaned for a while from the position of a horizontal (a lens optical axis is vertical), since the liquid which constitutes a lens drop moves to the slant bottom easily, the shape of surface type of a lens drop will change. When a rapid repetitive oscillation is added to the variable-focus lens equipment of the conventional technique or it is made to rotate the whole lens equipment rapidly around an optical axis, some liquids which constitute a lens drop dissociate irreversibly, and it may be able to stop moreover, being able to maintain the original lens configuration. Therefore, a necessary optical property is unrealizable to stability.
[0007] Then, the object of this invention is to control change of the shape of lens surface type over change of the external force which acts on a liquid lens in the variable-focus lens equipment which used the liquid lens, and maintain the shape of this lens surface type to stability.
[0008]
[Means for Solving the Problem] It is variable-focus lens equipment to which a focal location is changed by changing the configuration of the interface formed with the 1st liquid with which refractive indexes differ mutually as what attains the above-mentioned object, without mixing mutually, and the 2nd liquid according to this invention. Said the 1st liquid and said 2nd liquid are held in the cel, and said 2nd liquid forms the globule. Said 1st liquid is a conductive liquid containing a gelling agent, and said 2nd liquid is an insulating liquid. The globule surface of action in contact

with said globule is formed in the inner surface of said cel. It has an electrical-potential-difference impression means to impress an electrical potential difference between the electrode arranged through an insulating layer in the opposite hand at least with said 1st liquid and said 2nd liquid, and said 1st liquid. He is trying to change the configuration of said interface by changing the applied voltage by this electrical-potential-difference impression means, and variable-focus lens equipment ** characterized by the part of the transit route of close outgoing radiation light [as opposed to said interface at least] of said cel having translucency is offered.

[0009] This invention sets like 1 voice and said globule surface of action is a surface field where the affinity to said 2nd liquid is higher than a perimeter. This invention sets like 1 voice and said globule surface of action makes a circle configuration.

[0010] This invention sets like 1 voice, and the affinity to said 2nd liquid forms a surface layer lower than said insulating layer on said insulating layer, and said globule surface of action forms surface-layer opening in this a part of surface layer, and is formed from a part for the exposure insulation layer obtained by exposing said a part of insulating layer through this surface-layer opening.

[0011] 1 voice of this invention -- like -- setting -- said globule surface of action -- said insulating-layer top -- a surface layer -- forming -- this a part of surface layer -- said part obtained in a field by making it the affinity to said 2nd liquid become low from another sections field -- it is formed from the field.

[0012] This invention sets like 1 voice and said gelling agent consists of a polymeric material or supramolecular structure matter. This invention sets like 1 voice, said 1st liquid is a hydrophilic liquid, and said 2nd liquid is a hydrophobic liquid. This invention sets like 1 voice and said insulating layer thickness is 1 micrometer or less.

[0013] It has the bottom member and upside member of this invention which are set like 1 voice and by which said cel of each other has been arranged at parallel, and said insulating layer is formed on the top face of said bottom member. This invention sets like 1 voice and said electrode has electrode opening in the location corresponding to said globule surface of action. This invention sets like 1 voice and said electrode opening is smaller than said globule surface of action.

[0014] This invention sets like 1 voice, said cel has the cylindrical side-face member and the base member, said insulating layer is formed on the inner surface of said side-face member, and said surface layer is formed in the upper part of said side-face member so that said insulating layer may be exposed in the lower part of said side-face member.

[0015]

[Embodiment of the Invention] Hereafter, the gestalt of concrete operation of the variable-focus lens equipment of this invention is explained, referring to a drawing.

[0016] Drawing 1 is the typical sectional view showing the configuration of the 1st operation gestalt of the variable-focus lens equipment by this invention.

[0017] In drawing 1 , it is arranged so that the translucency plate-like bottom member 18 as a cel member and translucency plate-like upside member 18' may be parallel mutually, and the cel 19 is constituted. In the cel 19, the globule 11 which consists of an insulating liquid as the conductive liquid 13 and the 2nd liquid as the 1st liquid is held. The insulating layer 12 is formed on the top face (field of the cel inside) of the bottom member 18, and the globule 11 is in contact with the insulating layer 12. On the insulating layer 12, the surface layer 14 which the compatibility (affinity) over a conductive liquid 13 becomes from the compatibility over an insulating liquid size is formed. This surface layer 14 has an affinity lower than an insulating layer 12 to an insulating liquid. Circular surface-layer opening 14E is formed in the surface layer 14, and the globule 11 is located in this surface-layer opening 14E. A part of exposure **** insulating layer 12 constitutes the globule surface of action 15 through this surface-layer opening 14E.

[0018] The electrode 16 located in the insulating-layer 15 bottom is formed in the top face of the bottom member 18. Circular electrode opening 16E is formed in this electrode 16. This electrode opening 16E is arranged concentrically in the location corresponding to surface-layer opening 14E, and has a diameter smaller than surface-layer opening 14E. An electrical-potential-difference impression means V to impress an electrical potential difference between this electrode 16 and the electrode 17 arranged so that a conductive liquid 13 may be contacted is arranged. As an electrode 17, the conductive film formed on the internal surface of upside member 18' can be used. In addition, although direct current voltage is sufficient as the electrical potential difference impressed by the electrical-potential-difference impression means V, in order to control the charge impregnation to an insulating layer 12, it is desirable to use the alternating voltage of several 10Hz - 10kHz of numbers.

[0019] Refractive indexes can differ mutually, without mixing mutually, and the globule 11 of a conductive liquid 13 and an insulating liquid can change the configuration of the interface (lens side) formed of a conductive liquid 13 and

the insulating liquid globule 11 by changing the applied voltage of the electrical-potential-difference impression means V. A hydrophobic liquid can be used as an insulating liquid which constitutes a globule 11, using a hydrophilic liquid as a conductive liquid 13.

[0020] A conductive liquid 13 contains a conductive component and a gelling agent. As a conductive component of a conductive liquid 13, the thing in which itself has conductivity or the liquids which were made into conductivity by adding an ionicity component, such as a water solution, an organic liquid, etc. of mineral salt, can be used.

[0021] As a gelling agent contained in a conductive liquid 13, what consists of a polymeric material can be raised first. As for the polymeric materials used by this invention, it is desirable to have radicals, such as a hydroxyl group, a carboxyl group, a sulfo KISHIRU radical, a ether group, and an amide group, in a side chain or a principal chain in the chemical structure.

[0022] As such polymeric materials, polyvinyl alcohol, a polyethylene glycol, polyhydroxyethyl methacrylate, polyacrylic acid, polystyrene sulfonate, the polymethyl vinyl ether, polyacrylamide, its low-grade alkylation polymer, etc. are illustrated as a synthetic macromolecule ingredient.

[0023] Moreover, as a naturally-ocurring-polymers ingredient, protein, such as polysaccharide, such as starch, an alginic acid, and an agar, and a natural gum-like ingredient, gelatin, a polypeptide, a collagen, casein, etc. is illustrated.

[0024] These macromolecule system gelling agents are gel electrolytes which come to include a liquid electrolyte in a polymer matrix by combining with a conductive component. In a gel electrolyte, a polymer matrix does not contribute to ionic conduction fundamentally only by having the function which includes a liquid electrolyte. In a polymer matrix, since ion can be moved comparatively freely, the ionic conductivity of a gel electrolyte shows the high value according to a liquid electrolyte.

[0025] As a gelling agent contained in a conductive liquid 13 next, what consists of supramolecular structure matter can be raised. The supramolecular structure matter is matter which forms the aggregate with the structure of having geometric order with the compound of the type which takes supermolecule structure, i.e., the interaction of the weak force committed between molecules, (self-organizing, self-integration). The hydrogen bond which is called the noncovalent bond unlike the covalent bond mutually connected with the interaction of the weak force committed between molecules firmly by sharing an electron, ionic bond, a hydrophobic bond, electrostatic force, van der The Waals force, a charge transfer interaction, etc. are raised. Although such bonding strength is 1/dozens compared with the bonding strength of covalent bond, many joints exist, or it becomes and the firm aggregate is formed.

[0026] if a supermolecule is described further, in the living thing field, forming the molecular complex by which the supermolecule began structure formation (cytopoiesis etc.) of a living thing, met selectively by a various metabolic turnover process, signal transduction (enzyme reaction etc.) (meeting of DNA), etc., and was systematized very strictly, and the film will get to know -- having -- **** -- consequently, a component -- a function which is not seen when independent, and the reaction regioselective to altitude and stereoselective are realized. Moreover, structure can be changed if needed and self-repair, a chemical reaction, etc. can be performed very efficiently. Thus, by the conventional polymeric material which consists of covalent bond, the strict order structure and the new function which are not obtained are obtained by taking supramolecular structure.

[0027] As supramolecular structure matter used by this invention, a thing with steroid structure is desirable, and a sodium deoxycholate is mentioned as the example. To the supramolecular structure matter, pH regulator may be added if needed. The above-mentioned ingredient forming spiral fiber in a water solution at the time of suitable pH, and forming gel according to construction of a spiral chain is known (731 4 38 protein nucleic-acid enzyme Vol. No. p. 1993).

[0028] A liquid 13 can be made to gel by including the above gelling agents in a conductive liquid 13, without changing most conductivity. An important thing answers the configuration change by the electrical potential difference of a globule 11, and I hear that the gelled conductive liquid 13 uses the stimulus responsibility of gel of changing the configuration of an interface with a globule 11, and it has it here. For that purpose, it is desirable to carry out to the content of the gelling agent in a conductive liquid 13, for example, 0.1 - 50 % of the weight, and with such within the limits, the stimulus responsibility of gel can be demonstrated.

[0029] If there are too few contents of the gelling agent in a conductive liquid 13, the improvement in sufficient mechanical strength (improvement in the control function of lens side configuration change to change of external force) will no longer be obtained. Moreover, if there are too many contents of a gelling agent, the conductivity of a conductive liquid 13 and optical transparency fall, or when driver voltage is impressed, the response time of configuration change of the interface of the insulating liquid globule 11 and a conductive liquid 13 will become extremely long, or buildup of the contact angle theta will become difficult.

[0030] As an insulating liquid which constitutes a globule 11, the insulating liquid which is not mixed with the conductive liquids 13, such as silicone oil and paraffin oil, can be used, for example. Preferably, a globule 11 has a refractive index larger than a conductive liquid 13.
[0031] As an insulating layer 12, the ingredient which can form very little uniform film of a defect can be used. You may process if needed for making the front face of an insulating layer 12 into hydrophobicity. As for the thickness of an insulating layer 12, for reduction of the driver voltage of the electrical-potential-difference impression means V, it is desirable that it is 1 micrometer or less.
[0032] as the example of such an insulating layer 12 -- Langmuir-Blodgett (LB) -- the film (LB film) formed by law is raised. According to the LB method, a uniform defect-free thin film can be obtained by ordinary temperature and ordinary pressure.
[0033] Next, the cast coat film is raised as other examples of an insulating layer 12. This film can be formed by applying organic and an inorganic compound (preferably resin of a fluorine system or a silicon system) on a substrate using the technique of DIPINGU, a spin coat, etc. with a solvent. Furthermore, the film produced by sputtering, such as a metallic oxide and silicon, can be used.
[0034] A surface layer 14 consists of a hydrophilic ingredient, and, generally can use a well-known hydrophilic ingredient as this hydrophilic ingredient.
[0035] It is located, as, as for a globule 11, the underside section contacts the surface field 15 of the exposure **** insulating layer 12 in surface-layer opening 14E since the affinity [as opposed to / to an insulating layer 12 rather than / conductive liquid / 13 / compatibility / as opposed to / rather than / as opposed to / in this way / a surface layer 14 / globule / 11 / an insulating layer 12 / is large, and / a surface layer 14] is large, and the top-face section contacts a conductive liquid 13 and a lens side is formed, and a conductive liquid 13 is located further in contact with a surface layer 14. Thus, a surface layer 14 has the function to restrict horizontal migration of a globule 11 and to hold this globule in a predetermined location.
[0036] When the applied voltage by the electrical-potential-difference impression means V is zero, a globule 11 is in the condition by which it is shown by "A." The shaft shown by "C" is vertical to the globule surface of action 15, and passes along the core of this field. The globule 11 is located considering Shaft C as a core, and this shaft C turns into an optical axis of a lens side. Each part (for example, part corresponding to electrode opening 16E) of the equipment contiguous to an optical axis C is transparent.
[0037] Since the part which adjoins the opening 16E is located inside surface-layer opening 14E (namely, side near an optical axis C), an electrode 16 sees in the direction of an optical axis C, and the periphery section of a globule 11 is located so that it may lap with the inner edge of an electrode 16.
[0038] If an electrical potential difference is impressed among electrodes 16 and 17 by the electrical-potential-difference impression means V, according to the principle of electrowetting mentioned above, contact to a conductive liquid 13 and an insulating layer 12 will be started. This contact begins from the part near [which electric field concentrate] the electrode opening edge (namely, part around a globule 11), the interface of the insulating liquid globule 11 and a conductive liquid 13 is moved by this, and a globule 11 deforms into the condition by which it is shown with the broken line of "B." Extent of this deformation is controllable by the magnitude of the applied voltage by the electrical-potential-difference impression means V.
[0039] Thus, the focus of the lens of a globule 11 can be changed. In this operation gestalt, deformation (namely, change of a focal location) of lens interface sufficient as an optical element is less than [of the electrical-potential-difference impression means V / driver voltage 10V] realizable by setting thickness of an insulating layer 12 to 1 micrometer or less.
[0040] theta (v) which the contact angle when impressing an electrical potential difference v between an electrode 16 and 17 is shown by "theta" in drawing 1 , and expressed theta as a function of an electrical potential difference v is [thickness / of an insulating layer 12] the dielectric constant of gamma and a vacuum about the boundary tension of epsilon and a globule 11 in the specific inductive capacity of d and an insulating layer 12 epsilon 0 When it carries out, they are the following formulas (1).

$$\cos\theta(v)-\cos\theta(0)=\varepsilon_0\varepsilon v^2/(2d\gamma) \quad \ldots\ldots (1)$$

Being come out and given is shown in the reference of above-mentioned Vallet, Berge, Vovelle and others. A formula (1) shows that theta changes and the configuration of a globule 11 can be controlled by electrical-potential-difference impression.
[0041] In addition, even if applied voltage v changes, based on the symmetric property of electric field, the optical axis C of the lens side of a globule 11 is maintained in the almost original location.

[0042] With this operation gestalt, each of bottom members 18 of a cel 19 and upside member 18' can be made into translucency, and close outgoing radiation of the light can be carried out facing up or downward in accordance with an optical axis C. However, incidence of the light is carried out to the sense a top (below), and it may be made to carry out outgoing radiation to the sense by giving a light reflex layer to either the bottom member 18 or upside member 18' the bottom (above). In any case, the part of the transit route of the close outgoing radiation light of a cel 19 has translucency.

[0043] Drawing 2 is the typical sectional view showing the configuration of the 2nd operation gestalt of the variable-focus lens equipment by this invention. In this Fig., the same sign is given to the member which has the same function also in above-mentioned drawing 1 .

[0044] With this operation gestalt, three ring-like electrodes 35, 36, and 37 arranged in the shape of the same axle are used for the surroundings of an optical axis C instead of the electrode 16 of the operation gestalt of drawing 1 . And corresponding to this, the electrical-potential-difference impression means V1, V2, and V3 for impressing an electrical potential difference between the ring-like electrodes 35, 36, and 37 and an electrode 17, respectively are used instead of the electrical-potential-difference impression means V of the operation gestalt of drawing 1 .

[0045] A globule 11 can be made to transform into the condition of B continuously from the condition of A with this operation gestalt by impressing an electrical potential difference on the conditions of V1 electrical-potential-difference <V2 electrical-potential-difference <V3 electrical potential difference, and changing continuously the applied-voltage value of each electrical-potential-difference impression means with the ring-like electrodes 35, 36, and 37.

[0046] Drawing 3 is the typical sectional view showing the configuration of the 3rd operation gestalt of the variable-focus lens equipment by this invention. In this Fig., the same sign is given to the member which has the same function also in the above-mentioned drawing 1 -2.

[0047] With this operation gestalt, three surface-layer fields 65, 66, and 67 arranged in the shape of the same axle around an optical axis C in the inside of a surface layer 14 are used instead of forming surface-layer opening 14E in the operation gestalt of drawing 1 . As for these surface layers 14 and the surface-layer fields 65, 66, and 67, extent of the compatibility over a conductive liquid 13 is weak gradually in this sequence (extent of the compatibility over a globule 11 is strong gradually). The globule surface of action 15 is formed from the surface-layer fields 65, 66, and 67.

[0048] The optical axis C at the time of a globule 11 deforming between the condition of A and the condition of B is maintainable good by forming the surface-layer fields 65, 66, and 67 with this operation gestalt.

[0049] Drawing 4 is the typical sectional view showing the configuration of the 4th operation gestalt of the variable-focus lens equipment by this invention. In this Fig., the same sign is given to the member which has the same function also in the above-mentioned drawing 1 -3.

[0050] With this operation gestalt, cylindrical side-face member 18a, translucency base member 18b, and translucency top-face member 18c are used as a cel member. The insulating layer 12 is formed on the inner surface of side-face member 18a, and the surface layer 14 is formed on the insulating layer 12 in the side-face member 18a upside. The globule 11 is located in contact with an insulating layer 12 in the side-face member 18a bottom.

[0051] With this operation gestalt, the ring-like electrodes 75, 76, 77, 78, and 79 of the axial symmetry centering on an optical axis C are arranged in a different height location on the outside of an insulating layer 12. Although the electrical-potential-difference impression means V is connected only to the electrode 75 in drawing 4 , it connects with other electrodes 76, 77, 78, and 79 suitably, and an electrical potential difference can be impressed to a desired ring-like electrode. It is made for an applied-voltage value to become small in order of the ring-like electrodes 75, 76, 77, 78, and 79, and it can be made to transform a globule 11 into the condition of B continuously from the condition of A by changing the applied-voltage value of each ring-like electrode continuously.

[0052]

[Example] Although an example is given and the variable-focus lens equipment of this invention is explained hereafter, this invention is not limited only to the following examples. In addition, in the following examples, the variable-focus lens equipment of the operation gestalt of drawing 1 was produced.

[0053] The insulating layer 12 which consists of LB film using the glass substrate (bottom member) 18 in which the golden electrode 16 was formed, with [example 1] vacuum deposition was formed. That is, similarly FC722 (3 M company make) which is a fluorine system ingredient was diluted with the fluorine system solvent FC77 (3 M company make) 20 times, and the diluted solution for LB film membrane formation was obtained. Next, this diluted solution was developed on the water surface of the LB film production equipment which consists of pure water with a water temperature of 20 degrees C, and surface pressure was raised to 10 mN/m. The substrate vertical drive of LB

film production equipment is already equipped with said glass substrate 18 with a golden electrode here, it dropped this substrate vertically to the water surface, and was stopped in the place where this substrate head was located in 1 inch under the water surface. Then, it was made to stop in the place where this substrate was raised at and this substrate head was mostly located in homotopic with the water surface. This both-way actuation was repeated and the thin film of FC722 was formed on said substrate at the rate 0.95 of an imprint. The substrate lifting lowering speed at this time was a part for 10mm/. This formed the insulating layer 12 which consists of LB film of 28nm of thickness.
[0054] Then, the part of the globule surface of action 15 of an insulating layer 12 was masked, the dip painting cloth of the solution which distributed in ethanol the silicon oxide which is a hydrophilic ingredient was carried out, and the surface layer 14 was formed by drying.
[0055] As an insulating liquid which constitutes a globule 11, the silicone oil (the Shin-etsu chemistry company make: KF54) of a consistency 1.1 was used with the refractive index 1.51.
[0056] What was adjusted as follows was used as a conductive liquid 13. That is, the gelation transparence solution which contains the room temperature fused salt slack 1-ethyl-3-methyl-imidazolium tetrafluoroborate (0.01 mol/l) as the sodium deoxycholate (0.01 mol/l) as a gelling agent and a conductive component and the tetrafluoro lithium phosphate (0.01 mols/(l.)) as a pH regulator underwater was adjusted.
[0057] Above globules 11 and conductive liquids 13 were stored in the cel 19 containing the bottom member 18 and upside member 18', and variable-focus lens equipment as shown in drawing 1 was obtained.
[0058] Moreover, variable-focus lens equipment (example of a comparison) was obtained like the example except having used what does not add a gelling agent and pH regulator as a conductive liquid 13 for the comparison.
[0059] Driver voltage was impressed to the variable-focus lens equipment obtained as mentioned above, and when it checked whether the focal distance of a lens would change reversibly, the example and the example of a comparison showed change of a reversible focus by ON of the electric field before and behind 10V, and OFF. Next, the lens configuration when leaning about 30 degrees of 60 degrees of 90 degrees of these equipments from a level condition was observed. Consequently, although it did not move in the example even if it leaned the lens globule 11 to which include angle The lens globule 11 begins to move [an angle of inclination] by the example of a comparison from per 30 degrees. At 60 degrees, even if the globule 11 did not return to the original location even if it moved to the completely low side and returned equipment horizontally after that, or it returned, it was divided in two pieces or three parts, and did not become one drop of a basis.
[0060] From the above result, by using what contains a gelling agent as a conductive liquid 13 showed that implementation of the improvement in a mechanical strength was possible. Moreover, by using a thin film with a thickness of 1 micrometer or less as an insulating layer 12 showed that low driver voltage-ization was also realizable.
[0061] Variable-focus lens equipment was obtained like the example 1 except using the gelation transparence solution which contains the sodium deoxycholate (0.01 mol/l) as a gelling agent, the sodium chloride (0.04 mols/(l.)) as a conductive component, and the glycylglycine (0.01 mols/(l.)) as a pH regulator underwater as a [example 2] conductive liquid 13.
[0062] Moreover, variable-focus lens equipment (example of a comparison) was obtained like the example except having used what does not add a gelling agent and pH regulator as a conductive liquid 13 for the comparison.
[0063] Driver voltage was impressed to the variable-focus lens equipment obtained as mentioned above, and when it checked whether the focal distance of a lens would change reversibly, the example and the example of a comparison showed change of a reversible focus by ON of the electric field before and behind 10V, and OFF. Next, the lens configuration when leaning about 30 degrees of 60 degrees of 90 degrees of these equipments from a level condition was observed. Consequently, although it did not move in the example even if it leaned the lens globule 11 to which include angle The lens globule 11 begins to move [an angle of inclination] by the example of a comparison from per 20 degrees. At 40 degrees, even if the globule 11 did not return to the original location even if it moved to the completely low side and returned equipment horizontally after that, or it returned, it was divided in two pieces or three parts, and did not become one drop of a basis.
[0064] From the above result, by using what contains a gelling agent as a conductive liquid 13 showed that implementation of the improvement in a mechanical strength was possible. Moreover, by using a thin film with a thickness of 1 micrometer or less as an insulating layer 12 showed that low driver voltage-ization was also realizable.
[0065] Variable-focus lens equipment was obtained like the example 1 except using the gelation transparence solution which contains the polyvinyl alcohol (partial saponification mold PVA- 217; whenever [saponification] 88%; Kuraray Co., Ltd. make) (4wt%) as a gelling agent, and the sodium chloride (10wt%) as a conductive component underwater as a [example 3] conductive liquid 13.
[0066] Moreover, variable-focus lens equipment (example of a comparison) was obtained like the example except

having used what does not add a gelling agent as a conductive liquid 13 for the comparison.
[0067] Driver voltage was impressed to the variable-focus lens equipment obtained as mentioned above, and when it checked whether the focal distance of a lens would change reversibly, the example and the example of a comparison showed change of a reversible focus by ON of the electric field before and behind 10V, and OFF. Next, the lens configuration when leaning about 30 degrees of 60 degrees of 90 degrees of these equipments from a level condition was observed. Consequently, although it did not move in the example even if it leaned the lens globule 11 to which include angle The lens globule 11 begins to move [an angle of inclination] by the example of a comparison from per 15 degrees. At 25 degrees, even if the globule 11 did not return to the original location even if it moved to the completely low side and returned equipment horizontally after that, or it returned, it was divided in two pieces or three parts, and did not become one drop of a basis.
[0068] From the above result, by using what contains a gelling agent as a conductive liquid 13 showed that implementation of the improvement in a mechanical strength was possible. Moreover, by using a thin film with a thickness of 1 micrometer or less as an insulating layer 12 showed that low driver voltage-ization was also realizable.
[0069]
[Effect of the Invention] As explained above, according to the variable-focus lens equipment of this invention, by using the conductive liquid containing a gelling agent, a mechanical strength can improve, change of the shape of lens surface type over change of the external force which acts on a liquid lens can be controlled, and the shape of this lens surface type can be maintained to stability.
[0070] Moreover, change of a focal location is easily realizable by very low driver voltage using a thing with a thickness of 1 micrometer or less as an insulating layer.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

Claim(s)]
Claim 1] It is variable-focus lens equipment to which a focal location is changed by changing the configuration of the nterface formed with the 1st liquid with which refractive indexes differ mutually, without mixing mutually, and the 2nd iquid. Said the 1st liquid and said 2nd liquid are held in the cel, and said 2nd liquid forms the globule. Said 1st liquid is ı conductive liquid containing a gelling agent, and said 2nd liquid is an insulating liquid. The globule surface of action ir contact with said globule is formed in the inner surface of said cel. It has an electrical-potential-difference impression neans to impress an electrical potential difference between the electrode arranged through an insulating layer in the pposite hand at least with said 1st liquid and said 2nd liquid, and said 1st liquid. It is variable-focus lens equipment haracterized by trying to change the configuration of said interface by changing the applied voltage by this electrical-otential-difference impression means, and the part of the transit route of the close outgoing radiation light [as opposed o said interface at least] of said cel having translucency.
Claim 2] Said globule surface of action is variable-focus lens equipment according to claim 1 characterized by the ıffinity to said 2nd liquid being a surface field higher than a perimeter.
Claim 3] Said globule surface of action is variable-focus lens equipment according to claim 2 characterized by making a ircle configuration.
Claim 4] Said globule surface of action is variable-focus lens equipment according to claim 2 to 3 characterized by for he affinity to said 2nd liquid forming a surface layer lower than said insulating layer on said insulating layer, forming urface-layer opening in this a part of surface layer, and being formed from a part for the exposure insulation layer btained by exposing said a part of insulating layer through this surface-layer opening.
Claim 5] said globule surface of action -- said insulating-layer top -- a surface layer -- forming -- this a part of surface ayer -- said part obtained in a field by making it the affinity to said 2nd liquid become low from another sections field -- he variable-focus lens equipment according to claim 2 to 3 characterized by being formed from a field.
Claim 6] Variable-focus lens equipment according to claim 1 to 5 characterized by being what said gelling agent ecomes from a polymeric material.
Claim 7] Variable-focus lens equipment according to claim 1 to 5 characterized by being what said gelling agent ecomes from the supramolecular structure matter.
Claim 8] It is variable-focus lens equipment according to claim 1 to 7 which said 1st liquid is a hydrophilic liquid and is haracterized by said 2nd liquid being a hydrophobic liquid.
Claim 9] Said insulating layer thickness is variable-focus lens equipment according to claim 1 to 8 characterized by eing 1 micrometer or less.
Claim 10] It is variable-focus lens equipment according to claim 1 to 9 which said cel has the bottom member and ıpside member which have been arranged at parallel, and is characterized by forming said insulating layer on the top ace of said bottom member.
Claim 11] Said electrode is variable-focus lens equipment according to claim 1 to 10 characterized by having electrode pening in the location corresponding to said globule surface of action.
Claim 12] Said electrode opening is variable-focus lens equipment according to claim 11 characterized by being smaller han said globule surface of action.
Claim 13] It is variable-focus lens equipment according to claim 4 to 9 which said cel has the cylindrical side-face nember and the base member, and said insulating layer is formed on the inner surface of said side-face member, and is haracterized by forming said surface layer in the upper part of said side-face member so that said insulating layer may e exposed in the lower part of said side-face member.
